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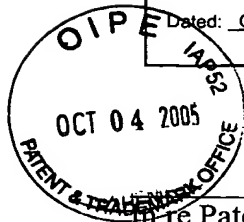
Dated: October 4, 2005

Signature:

(Robert G. Gingham)

AF
JFW

Docket No.: S2856.0022
(PATENT)



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:

Ichiro Mase et al.

Application No.: 09/900,771

Confirmation No.: 7693

Filed: July 6, 2001

Art Unit: 1773

For: HEAT CONTROL METHOD AND HEAT
CONTROLLER

Examiner: N. J. Uhler

APPEAL BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

As required under § 41.37(a), this brief is filed within two months of the Notice of Appeal filed in this case on August 4, 2005, and is in furtherance of said Notice of Appeal.

The fees required under § 41.20(b)(2), and any required petition for extension of time for filing this brief and fees therefor, are dealt with in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief contains items under the following headings as required by 37 C.F.R. § 41.37 and M.P.E.P. § 1206:

- | | |
|------|-----------------------------------|
| I. | Real Party In Interest |
| II | Related Appeals and Interferences |
| III. | Status of Claims |
| IV. | Status of Amendments |
| V. | Summary of Claimed Subject Matter |

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VI.	Grounds of Rejection to be Reviewed on Appeal
VII.	Argument
VIII.	Claims
IX.	Evidence
X.	Related Proceedings
Appendix A	Claims
Appendix B	Declaration

I. REAL PARTY IN INTEREST

The real party in interest for this appeal is:

NEC Corp.

II. RELATED APPEALS, INTERFERENCES, AND JUDICIAL PROCEEDINGS

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 19 claims pending in application.

B. Current Status of Claims

1. Claims canceled: 2.
2. Claims withdrawn from consideration but not canceled: none.
3. Claims pending: 1, 3-20.
4. Claims allowed: none.
5. Claims rejected: 1, 3-20.

C. Claims On Appeal

The claims on appeal are claims 1, 3-20.

IV. STATUS OF AMENDMENTS

Applicant filed an Response to the Final Rejection on June 29, 2005. At that time, no amendments were made to the claims. The Examiner responded to the Response in an Advisory Action mailed July 13, 2005.

Accordingly, the claims enclosed herein as Appendix A reflect the status of the claims on and before June 29, 2005.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The present invention describes an apparatus and a method for controlling the temperature in an object, such as a space vehicle. The apparatus comprises a two-layer composite material. As shown in Fig. 1, the first layer is a base material 2 in thermal contact with the object 3. The base material 2 radiates large amounts of heat (in the form of thermal, infrared radiation) when the object 3 and the base material 2 are at high temperatures. The second layer comprises a thin layer of phase-change substance 1, having a thickness of about one to about thirty microns.

The second layer has two temperature-dependent phases: a low-temperature phase and a high-temperature phase. In the low-temperature phase, the second layer has metallic

properties (conducts heat), radiates a relatively small amount of heat, and reflects heat radiation. In the high-temperature phase, the second layer radiates heat, and allows heat radiation to pass through it. Specification, p. 8, ll. 17-29.

With this configuration, the composite material can control the object's temperature. With reference to Fig. 1:

[W]hen the temperature of the object 3 drops, because the temperature of the base material 2 that is thermally joined thereto also drops, the temperature of the phase-change substance 1 that is applied thereover by painting or vapor deposition or the like also decreases. When the phase-change substance 1 drops below its phase-transition temperature, the radiation ratio thereof decreases, so that the amount of heat radiated to the external environment decrease, making it possible to limit the decrease in temperature of the object 3.

Specification, p. 12, ll. 18-27. The thin phase-change layer blocks heat from radiating away when the phase-change layer is in the low-temperature phase.

In contrast, if the temperature of the object increases, the temperature of the base layer 2 and the phase-change layer 1 will also increase. The phase-change layer will transition to the high-temperature phase, which permits heat radiation to pass through it. "Although it is not possible for the phase-change substance 1 to radiate sufficient heat because of its thinness," the base material 2 has a high heat radiation ratio, and thus can convert sufficient heat into infrared radiation. "[T]he heat radiated from the base material 2 forming the underlayer thereof, which has a high heat radiation ratio, passes through the phase-change substance 1, [increasing] the amount of heat radiated into the external environment, thereby enabling a limitation of the temperature rise in the object 3." Specification, p. 13, ll. 3-12.

The claimed method comprises attaching an above-described phase-change layer to a first surface of a base material, and attaching a second surface of the base material to an object. Claim 13.

VI. GROUNDS OF OBJECTION TO BE REVIEWED ON APPEAL

Claims 1 and 3-20 are pending in the present application. Independent claims 1 and 13, and dependent claims 4, 5, 8, 9, 12, 15, 16 and 18-20 have been rejected under 35 U.S.C. § 103(a) over Long et al. (U.S. Patent 6,176,453) in view of Okamoto et al. (EP 0919647 A1 – EP ‘647). Dependent claims 3, 6, 7, 14 and 17 have been rejected under 35 U.S.C. § 103 over Long in view of Okamoto further in view of Bable et al. (U.S. Patent 5,296,285). Dependent claim 10 is rejected under 35 U.S.C. § 103 over Long and Okamoto further in view of Bjorndahl et al. (U.S. Patent 6,005,771). Dependent claim 11 has been rejected under 35 U.S.C. § 103 over Long and Okamoto further in view of Dalby (U.S. Patent 4,669,685).

VII. ARGUMENT

All of the rejections of the claims of the present application are based on the Office Action dated August 4, 2004. On October 20, 2004, Applicants filed a Response to that Office Action arguing that the Okamoto reference, the only reference applied against the claims of the present application for a phase change layer, only taught one skilled in the art to create a phase change layer that is several hundred microns thick. In the Advisory Action dated October 28, 2004, the Examiner conceded that:

Applicants have a point, but their argument is flawed in one critical way. Applicant's argument presupposes the fact that Okamoto tested the manganese perovskite oxide film of their invention, and it determined that films that were thinner/thicker than "several hundred microns" were not suitable. However, there is no teaching in Okamoto that films having a thickness other than "several hundred microns" are "bad" or "unsuitable" for use on spacecraft.

Applicants filed a RCE and submitted an Affidavit from Mr. Okamoto in response to the Examiner's observations. Specifically, Mr. Okamoto states that it would not have been obvious to one skilled in the art to create a phase change layer of 1-30 microns thick from the reading of the EP ‘647, because at the time, it was not known how to form a layer that had a thickness of less than 200 microns.

The Examiner has stated that he has considered the Affidavit of Mr. Okamoto but respectfully disagrees with Mr. Okamoto's conclusions.

In the first full paragraph on page 4 of the Final Office Action mailed March 31, 2005, the Examiner notes that "applicants claims are not commensurate in scope with the argument presented. The only material that applicants have allegedly shown could not be formed at a thickness of 1-30 microns is a perovskite manganese film, which is not required in all the claims." In the instant Advisory Action mailed July 13, 2005, the Examiner continues to assert that the reference cited is not commensurate in scope with the claim. Any incongruence in scope should be attributed to the Examiner's rejection, which cites the EP '627 reference. Applicants respectfully point out, as the Examiner has admitted, that EP '647 recites the broad class of perovskite manganese oxides. The Examiner has not applied references disclosing a phase change layer besides EP '647. Mr. Okamoto's Affidavit discussed the perovskite (manganese) film, because that was the subject matter of Mr. Okamoto's EP '647 reference, which the Examiner cited against the claims of the present application.

In the second full paragraph on page 4 of the Final Office Action mailed March 31, 2005, the Examiner addresses Mr. Okamoto's statement that the inventors of EP '647 were not able to achieve thinner layers of the phase-change layer. The Examiner "notes that many prior art methods of depositing perovskite (manganese) oxides are capable of achieving these thickness ranges (see cited, pertinent prior art below)." Yet, the Examiner has not applied any of these references against the claims of the present application. Despite the Examiner's assertion in the July 13, 2005 Advisory Action that he has "pointed to [a] plethora of prior art references which teach differently, albeit utilizing a different method of production of the perovskite oxide films," the only reference cited for depositing phase-change materials that any of the Office Actions have applied against the claims of the present application is the Okamoto EP '647 reference. Applicants respectfully submit that the Declaration of Mr. Okamoto overcomes the rejection of the claims of the present application based on his reference EP '647. Applicants have not had the opportunity to address any further rejection combining the Long reference, the Okamoto reference and any third references with respect to the formation of a 1-30 micron phase change substance layer.

Ultimately, should one of such plethora of new references be cited against the claims of the present application, applicants respectfully request withdrawal of the finality of the present rejection.

In addition, in the second full paragraph on page 4 of the March 31, 2005 Final Office Action, the Examiner notes an “extremely strong desire to reduce weight for space applications, and such desire would necessarily lead to the desire to reduce thickness values for various layers.” Id. In the July 13, 2005 Advisory Action, the Examiner still has not shown why one of ordinary skill would be motivated to combine a base layer with a thinner phase-change layer. Utilizing improper hindsight, the Examiner states that “the base layer is taught as noted in the rejection of record and the motivation for the reduced thickness is deemed to be clearly within the knowledge of one of ordinary skill in the art, given that the disclose application would be a space-based application requiring the control of the weight (and hence, thickness).”

In order to present a prima facie case of obviousness, inter alia, the Examiner is required to show both a teaching or suggestion to modify the reference and that there must be a reasonable expectation of success. “The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant’s disclosure.” MPEP § 2143 (emphasis added). The Examiner has failed to show where the EP ‘647 reference teaches such motivation, i.e. : (1) how to make a thinner phase change layer; (2) why a thinner phase change layer needs to be combined with an additional base layer, and (3) how such combination could reasonably be expected to successfully remove the heat from the object.

As Mr. Okamoto’s declaration states, “[w]hen the EP application was filed, it was not known that the SRD could have a thickness of less than 200 microns.” Okamoto Declaration, ¶ 6. The Examiner has failed to cite where the EP ‘627 reference teaches how to make a thinner phase change layer, or any reference for this teaching.

It was the inventors who discovered that the combination of a base layer and a thin phase change layer overcame the deficiencies of the prior art thick layer. As taught in the detailed description of the present invention, “[a]lthough it is not possible for the [thinner]

phase-change substance 1 to radiate sufficient heat because of its thinness, the heat radiated from the base material 2 forming the underlayer thereof, which has a high heat radiation ratio, passes through the phase-change substance 1, it is possible to achieve a large amount of heat radiated from both of these elements combined.” Specification, p. 13, ll. 3-9. To achieve superlative performance, the invention requires that the “phase-change substance comprises a thickness in the range from about one to about thirty microns,” (Claim 1, ll. 12-13) in combination with a base material beneath the phase-change substance that “radiates a larger amount of heat at a high temperature . . . having a surface adapted to thermally contact a surface of said object.” Claim 1, ll. 3-5. “For this reason, there is an increase in the amount of heat radiated into the external environment, thereby enabling a limitation of the temperature rise in the object 3.” Specification, p. 13, ll. 10-12. The Examiner cites no authority for these teachings disclosed by the applicants, and thus has not made a prima facie case of obviousness.

As discussed in the background section of applicants’ disclosure, “because it is necessary to achieve a high radiation efficiency with the phase-change substance alone at a high-temperature phase, it was necessary to have a thickness of several hundred microns.” Specification, p. 4, ll. 10-13. Thus, there could be no reasonable expectation of success by merely reducing the thickness of the phase-change layer, as the Examiner suggests in the Office Action.

Applicants respectfully submit that the Affidavit of Mr. Okamoto submitted concurrently with the filing of an RCE in the present application successfully overcame the rejection of the claims of the present application based on the Okamoto reference EP ‘647. As Mr. Okamoto is clearly one skilled in the art, applicants respectfully submit his observations and statements regarding the state of the art should be given great deference.

VIII. CLAIMS

A copy of the claims involved in the present appeal is attached hereto as Appendix A.

IX. EVIDENCE

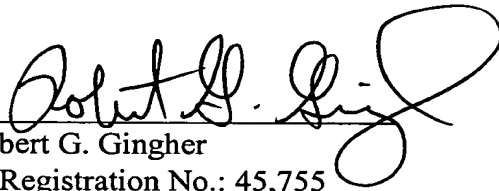
A copy of Mr. Akira Okamoto's December 24, 2004 Declaration, previously submitted in a January 20, 2005 Response to Office Action concurrently with the filing of an RCE, and pursuant to 37 C.F.R. § 1.132, is attached hereto as Appendix B.

X. RELATED PROCEEDINGS

No related proceedings are referenced in II. above, or copies of decisions in related proceedings are not provided, hence no Appendix is included.

Dated: October 4, 2005

Respectfully submitted,

By 
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Registration No.: 45,755

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APPENDIX A

Claims Involved in the Appeal of Application Serial No. 09/900,771

1. (Previously Presented) A composite material heat controller for an object, the composite material heat controller comprising:
 - a base material that radiates a larger amount of heat at a high-temperature relative to that of the heat radiated at a low-temperature, the base material having a surface adapted to thermally contact a surface of said object; and
 - a phase-change substance overlying said base material having insulation properties at the high-temperature, metallic properties at the low-temperature, radiating a larger amount of heat at the high-temperature relative to a smaller amount of heat radiated at the low-temperature, and having a high reflectivity in the thermal infrared light region at the low-temperature;wherein said phase-change substance comprises a thickness in the range from about one to about thirty microns.
2. (Canceled).
3. (Previously Presented) The composite material heat controller according to claim 1, wherein said base material comprises a thickness greater than a thickness of said phase-change substance.
4. (Previously Presented) The composite material heat controller according to claim 1, wherein said phase-change substance is a perovskite oxide.
5. (Previously Presented) The composite material heat controller according to claim 4, wherein said phase-change substance 1 is perovskite Mn oxide.
6. (Previously Presented) The composite material heat controller according to claim 1, wherein said base material comprises a thickness in the range from 10 to 100 μm .

7. (Previously Presented) The composite material heat controller according to claim 1, wherein said base material is selected from a group consisting of silicone, alumina, and partially stabilized-zirconia.

8. (Previously Presented) The composite material heat controller according to claim 1, wherein a reflective plate or reflective film each having reflectivity with respect to visible light is laminated onto said phase-change substance on a side opposite from a side on which said base material is laminated.

9. (Previously Presented) The composite material heat controller according to claim 1, wherein said surface of said base material of said composite material heat controller is affixed to the surface of the object either directly or via an intervening heat-conductive substance.

10. (Previously Presented) The composite material heat controller according to claim 9, wherein said composite material heat controller is thermally joined to said object, via an appropriate intervening adhesive.

11. (Previously Presented) The composite material heat controller according to claim 1, wherein said object comprises a non-flat surface.

12. (Previously Presented) The composite material heat controller according to claim 1, wherein said object includes an electronic circuit used in a space vehicle, including a man-made satellite and a spaceship.

13. (Previously Presented) A method for controlling heat in an object comprising:
providing a base material that radiates a larger amount of heat at a high-temperature relative to that of the heat radiated at a low-temperature, the base material having at least a first surface and a second surface;
attaching a phase-change substance on said first surface of said base material, said phase-changing substance having insulation properties at the high-temperature, metallic properties at the low-temperature, radiating a larger amount of heat at the high-temperature relative to a smaller amount of heat radiated at the low-temperature, and having a high reflectivity in the

thermal infrared region at the low-temperature phase and comprising a thickness in the range from about one to about thirty microns; and attaching said second surface of said base material to said object.

14. (Previously Presented) The method for controlling heat according to claim 13, wherein said base material comprises a thickness greater than a thickness of said phase-change substance.

15. (Previously Presented) The method for controlling heat according to claim 13, wherein said phase-change substance is a perovskite oxide.

16. (Previously Presented) The method for controlling heat according to claim 15, wherein said phase-change substance is perovskite Mn oxide.

17. (Previously Presented) The method for controlling heat according to claim 13, wherein said base material is selected from a group consisting of silicone, alumina and partially stabilized-zirconia.

18. (Previously Presented) The method for controlling heat according to claim 13, wherein either one of a reflective plate and a reflective film having reflectivity with respect to visible light is laminated onto said phase-change substance on a side opposite from a side attached to said first surface of said base material.

19. (Previously Presented) The method for controlling heat according to claim 13, wherein said composite material is attached to a surface of said object, either directly or via an intervening heat-conductive substance.

20. (Previously Presented) The method for controlling heat according to claim 13, wherein said object includes an electronic circuit used in a space vehicle, including a man-made satellite and a spaceship.

APPENDIX B

**Declaration Under Rule 132 of Mr. Akira Okamoto Submitted in the Appeal of
Application Serial No. 09/900,771**

Application No.: 09/900,771

Docket No.: S2856.0022/P022

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Ichiro Masc et al.

Application No.: 09/900,771

Filed: July 6, 2001

For: HEAT CONTROL METHOD AND HEAT
CONTROLLER



Art Unit: 1773

Examiner: N. J. Uhler

DECLARATION UNDER RULE 132

I, Akira Okamoto, hereby declare the following:

1. I am an inventor in European Patent Application No. EP 0919647A1 (the "EP application"), published June 2, 1999.
2. I am also an author of the article attached as Exhibit 1, entitled "Smart Radiation Device: Design of an Intelligent Material with Variable Emittance," Society of Automotive Engineers, Inc. (2001). This article describes the history of the Smart Radiation Device (SRD) since its initial development. The initial development of SRD was the subject of the EP application.
3. At the time of filing the EP application, our development of the SRD was such that we could only form a several hundred micron thick film. Specifically, "[t]he thickness of the SRD, which is initially composed of one material, was 200 um and its weight was about 1.2 kg/m² (SRD1)" (Exhibit 1, under the heading "Lightweight Technology," first paragraph). This statement in Exhibit 1 is consistent with the description of the SRD material in the EP application. As stated in the EP application, the SRD layer "is arranged on the surface 3 of the wall 2 in the form of a several hundred micron thick film" (col. 3, ll. 44-46).

Application No.: 09/900,771

Docket No.: S2856.0022/P022

4. After the EP application was filed, development of SRD devices continued. The objective was to reduce the thickness of SRD1, while retaining its strength and optical properties. As further noted in connection with the next iteration of the material, SRD2, "the thickness of the SRD could be reduced to 70 μm and its weight would be about 0.5 kg/m^2 (SRD2). However it was impossible to reduce the thickness more by grinding because the thin SRD doesn't have enough strength for the grinding process and it isn't easy to handle such a device" (Exhibit 1).

5. Subsequently, progress in the design and manufacturing of the SRD continued. "[B]y changing from the standard ceramic production to the printing technique," the thickness, and thereby the weight, of the SRD was further reduced (Exhibit 1, under the heading "Introduction," fourth paragraph). These changes were neither known nor contemplated when the EP application was filed.


6. When the EP application was filed, it was not known that the SRD could have a thickness of less than 200 microns.

7. Therefore, it would not have been obvious to one skilled in the art at the time of filing the EP application to make an SRD layer from 1 to 30 microns thick.

8. I further declare that all statements made herein are made of my own knowledge and are true except for those statements made on information and belief, which are believed to be true, and further that the statements were made with a knowledge that willful false statements or like so made are punishable but fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and such willful false statements may jeopardize the validity of this declaration and of any United States patent that this Declaration concerns.

December 27, 2004

Date



Akira Okamoto

EXHIBIT 1
TO AKIRA OKAMOTO DECLARATION

2001-01-2342

Smart Radiation Device: Design of an Intelligent Material with Variable Emittance

Sumitaka Tachikawa and Akira Ohnishi
The Institute of Space and Astronautical Science

Kazunori Shimazaki
Keio University

Akira Okamoto, Yasuyuki Nakamura, Yuichi Shimakawa,
Toru Mori and Atsushi Ochi
NEC corporation

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ABSTRACT

A variable emittance radiator, called SRD, is a thin and light ceramic tile whose infrared emissivity is varied proportionally by its own temperature. Bonded only to the external surface of spacecrafts, it controls the heat radiated to deep space without electrical or mechanical parts such as the thermal louver. By applying this new device for thermal control of spacecrafts, considerable weight and cost reductions can be achieved easily.

In this paper, the new design and the new manufacturing process of the SRD and its optical properties, such as total hemispherical emittance and the solar absorptance, are described. By introducing this new design and manufacturing process, the weight of the SRD is easily decreased, keeping its strength and the optical properties.

INTRODUCTION

The temperature of spacecrafts is affected by several factors in each respective mission phase. As a result, many technologies have been used for temperature control of spacecrafts. But the thermal control devices presently using conventional techniques are heavy and expensive. Therefore developing a lighter and more economical thermal control device, with high performance, is required.

The SRD can change its optical properties depending on temperature by its special property of metal-insulator transition. This allows emittance modulation of spacecrafts' surfaces and components without bulky devices that have moving parts or electrical instruments that have sensors and wires. The material of the SRD is a Ca substituted LaMnO₃ based perovskites, such as La_{1-x-y}Sr_xCa_yMnO₃ which contains X mol% of Sr and

Y mol% of Ca on La-sites. The SRD was presented for the first time to the 29th ICES Conference in Denver, Colorado, in July 1999. The first publication^[1] describes the principles of the SRD, the optical properties of the materials, La_{0.825}Sr_{0.175}MnO₃ and La_{0.7}Ca_{0.3}MnO₃, and the results of the proton irradiation test for these materials. The second publication^[2] in July 2000 describes the optical properties of the new material, La_{0.775}Sr_{0.115}Ca_{0.11}MnO₃, and the test results of the electron and UV irradiation for the old material, La_{0.825}Sr_{0.175}MnO₃.

Progress in the design and manufacturing process has been made since the last publication. In order to decrease the weight, the SRD production process was improved significantly by changing from the standard ceramic production to the printing technique. This paper describes the advances made during the continuing development activities.

LIGHTWEIGHT TECHNOLOGY

It is very important for space applications to produce light elements with a large proportion of effective surface area used for thermal control. The thickness of the SRD, which is initially composed of one material, was 200 μm and its weight was about 1.2 kg/m² (SRD1). By grinding the material, the thickness of the SRD could be reduced to 70 μm and its weight would be about 0.5 kg/m² (SRD2). However it was impossible to reduce the thickness more by grinding because the thin SRD doesn't have enough strength for the grinding process and it isn't easy to handle such a device. SRD2 are sliced from sintered block to ceramic wafers and ground to the required thickness, so the production process is tedious.

These difficulties can be overcome by introducing screen-printing techniques to the production process.

his process is called "Thick Film Process" and the fabrication process is as follows:

- Ceramic powder is made by using the same method as the standard ceramic production process.
- The powder is mixed with an organic vehicle that is composed of binder and solvent, and the powder is changed to a paste.
- The paste is printed on the ZrO_2 substructure by using the screen-printing technique.
- And then, it is fired at a high temperature (above $1000^\circ C$) for some hours.

is process is used for electronics device, such as chip sisters, ceramic gas sensors and humidity sensors. is method has the advantage that the SRD's thickness in be reduced under $70\mu m$, making the element faster id reducing its weight.

re schematics of the SRDs are shown in Figure 1. gure 1(a)(b) show conventional SRDs which are mposed of one material. In Figure 1(c), a thin ZrO_2 ate is about $50\mu m$ thick is used as a substructure reinforce the strength of the thin variable emittance er. That is to say, it serves as a backbone for the RD3. So the variable emittance layer on the bstructure of the SRD3 is under $20\mu m$. The density of O_2 is equal or a little smaller than the variable itance material, but it has stronger tenacity. ZrO_2 and $La_{0.775}Sr_{0.115}Ca_{0.11}MnO_3$ are used to make the electrodes and ctrolyte in solid oxide fuel cells, so the bonding ength between both materials is enough. As a result, thickness of the variable emittance material is under a tenth of the old one (SRD1). The SRD3 is thinner d it is also stronger than the SRD2. Table 1 is the mparison of the thickness, the number of layers and weight for the SRDs.

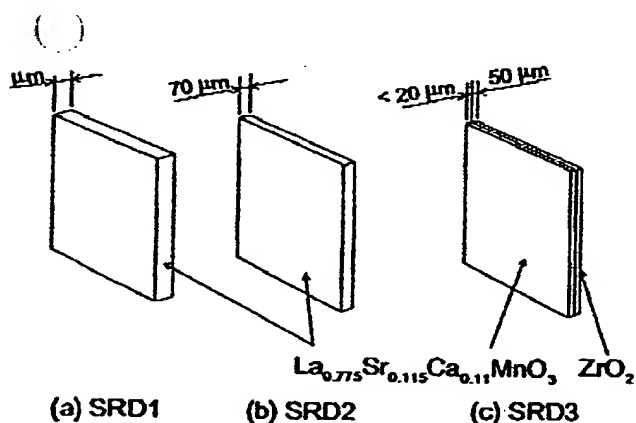


Figure 1. Schematic of SRDs.

Table 1. Comparison of thickness, the number of layers and weight of SRDs.

	SRD1	SRD2	SRD3
Thickness	$200\mu m$	$70\mu m$	$< 70\mu m^*$
Layers	1	1	2
Weight	$1.2kg/m^2$	$0.5kg/m^2$	$< 0.43kg/m^2$

*The thickness of SRD3 includes that of a substructure ($50\mu m$).

In using this "Thick Film Process", it is possible to attach the SRD directly on the surface of the instruments without using adhesive. That is to say, the panel of the instruments is used as the substructure instead of the ZrO_2 plate. Sensitive components of small mass could also be directly covered with the SRD coating to provide even better thermal control. The material suitable for direct application of the coating has to withstand the firing temperature.

EVALUATION OF EFFECTIVE THICKNESS – To work as the thermal control device, the SRD needs enough thickness to avoid transmission of thermal IR. But the thickness has to be minimal to reduce weight of the SRD. In order to evaluate the effective thickness, the spectral transmittance $T(\lambda)$ was calculated. It can be obtained by using the refractive index $n(\lambda)$ and the extinction coefficient $k(\lambda)$ which are calculated from the spectral reflectance $R(\lambda)$ by Kramers-Kronig analysis.^[4] The spectral Reflectance $R(\lambda)$ is measured by using the Fourier transform spectrometer (Bio-Rad FTS-60A/896).

Figure 2 shows the calculated results of the spectral transmittance $T(\lambda)$ on a wavelength region of $1\sim 100\mu m$ of the variable emittance layer for 173K, 293K and 353K. The thickness of the variable emittance layers used for calculation are 1, 5 and $10\mu m$. The transmittance of the $1\mu m$ and $5\mu m$ layer are under 25% and 10% each for wavelength region of $6\sim 100\mu m$. On the other hand, the transmittance of the $10\mu m$ layer is almost 0%. From these results, the effective thickness of the variable emittance layer for the SRD is about $5\sim 10\mu m$.

MEASUREMENT RESULTS OF OPTICAL PROPERTIES

The new SRD (SRD3) is a thin ceramic tile $30\times 30mm^2$ in size, about $59\mu m$ thick and weighs about $355g/m^2$. It is composed of a variable emittance layer and a substructure layer. The material of the variable emittance layer made in this research is $La_{0.775}Sr_{0.115}Ca_{0.11}MnO_3$ and the thickness is $9\mu m$. Figure 3 shows one of the SRD used for the measurement of the optical properties. The cables are thermocouples to measure the temperature and the heater power cables to control the temperature of the SRD. The surface of the materials

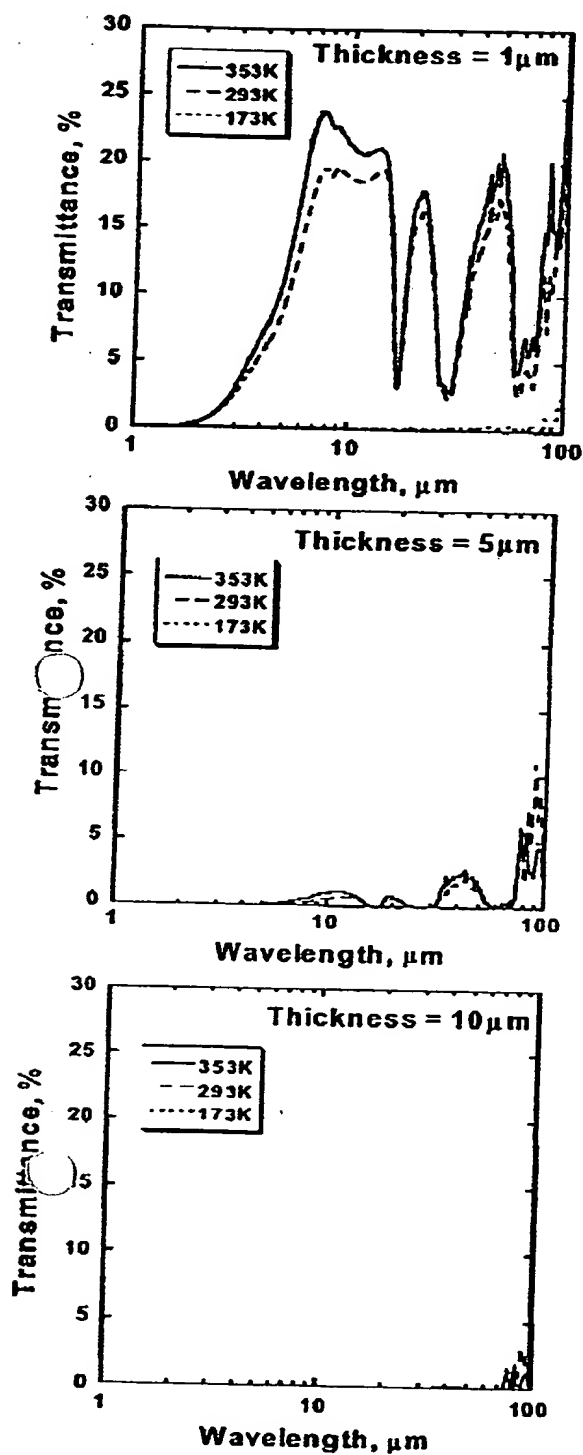


Figure 2. Spectral Transmittance of SRD with 1, 5 and μm thick on a wavelength range of 1–100 μm at 173K, 293K and 353K.

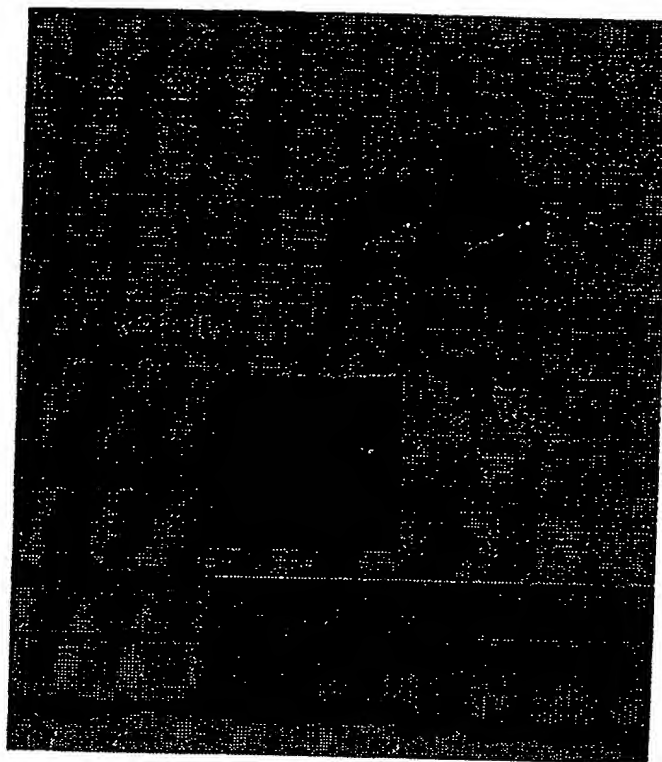


Figure 3. Test piece of SRD.

used for the measurement was left unfinished (i.e., all samples were not polished). Under ideal circumstances, this surface should be polished so that a comparison of optical properties would be more accurate. However, the surface conditions of all samples are practically the same, so the results are not influenced.

The total hemispherical emittance ϵ_H was measured by the calorimetric method¹⁹ for the temperature range between 173K and 373K, and the solar absorptance α_S was measured spectroscopically with an integrating sphere in the wavelength region of 0.26–2.5 μm .

TOTAL HEMISPHERICAL EMITTANCE - Figure 4 shows the temperature dependence of the total hemispherical emittance for SRD2 and SRD3. The material of SRD2 is the same as that of the variable emittance layer of SRD3. The emissivity of the SRD3 at both high and low temperatures is almost the same as that of the SRD2, and the variation in the emissivity is the same. An overview of their performance is given in Table 2.